PROPULSION DIRECTORATE

Monthly Accomplishment Report
April 2005

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AFRL'S NEWEST RAMJET PROPULSION TECHNOLOGY TRANSITIONS TO THE GQM-163A COYOTE: Orbital Sciences Corp. completed a critical flight test of the Navy's new GQM-163A Coyote supersonic sea skimming target on 22 April 2005. This flight completed a test series that convinced the Naval Air Systems Command (NAVAIR) to proceed with low rate initial production of the target system. The GQM-163A is propelled by Variable Flow Ducted Rocket (VFDR) propulsion technologies that were developed under a series of programs managed by AFRL's Propulsion Directorate. The VFDR is essentially an afterburning solid rocket, combining a fuel-rich gas generator with ramjet inlets, a combustion chamber, and a nozzle. VFDR propulsion technologies are well suited for supersonic tactical missiles, and are now being used in at least three development efforts by other organizations: the Coyote target, the Navy's High Speed Anti-Radiation Missile Demonstration, and the European Meteor Air-to-Air Missile. AFRL's Propulsion and Munitions Directorates continue to advance the technology suite, most recently via the Variable Flow Ducted Rocket Flight Vehicle Concepts program. (Mr. G. Liston, AFRL/PRA, (937) 255-2449)

The Mach 2.5+ Coyote target passing over the bow of a Navy ship midway through a 100 km flight that was conducted on 22 April 2005

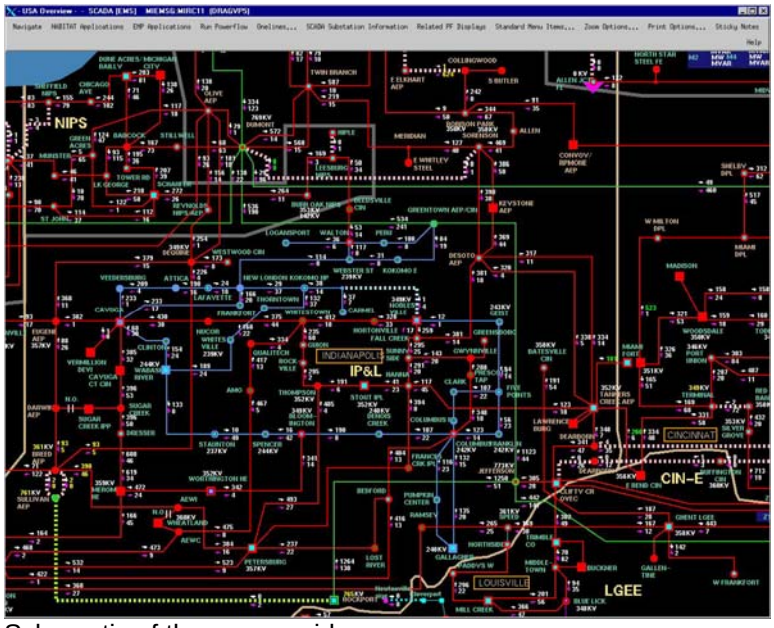
Want more information?

- An Orbital Sciences Corp. Press Release on this test flight program is available here.

AFRL TECHNOLOGY APPLIED TO TERRESTRIAL POWER GRID: Air Force installations in CONUS and overseas use power from electrical grid sources. Distributed Heterogeneous Simulation (DHS) technology is a valuable asset to examine the reliability and vulnerability of such systems. Under the DHS III project with PC Krause and Associates, Inc. (PCKA) and Purdue University, an investigation will occur on the usefulness of DHS in creating fast, accurate time-domain transient simulations of interconnected terrestrial power grids. The simulations, which include hundreds of power generating stations, interconnected distribution, and numerous levels of control, are to be used for studies of fast transients which can lead to instabilities and even massive collapses of the power grid, such as those recently experienced in the US and Canada. The work is being performed at the Purdue University Center for Security of Large Scale Systems and PCKA. In order to predict these events, very detailed models of the generators and their complex interconnections within the power distribution network must be

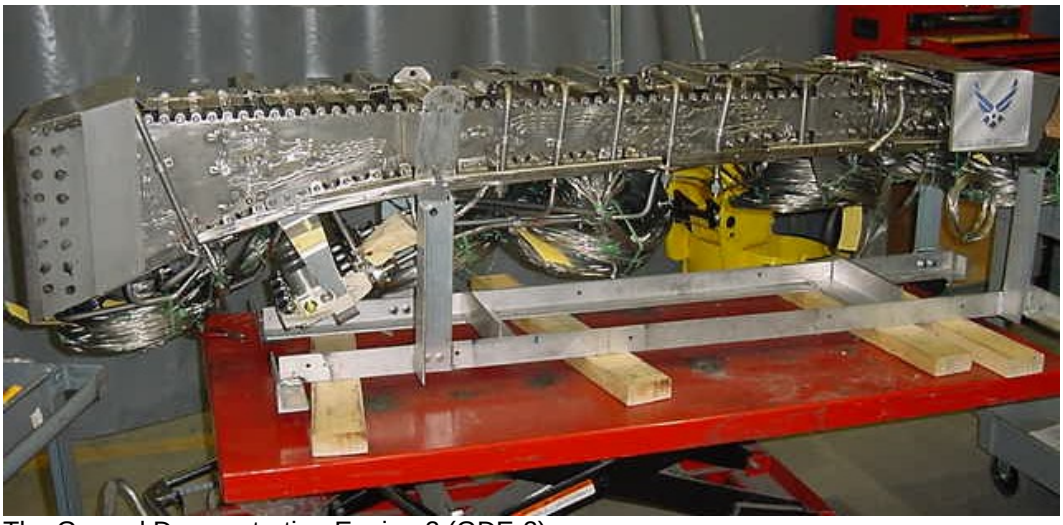
used. Purdue and PCKA are also working with the Midwest Independent System Operator, Inc. (MISO), which is responsible for the oversight and operation of the largest block of power in the world. The MISO maintains and exercises the largest "state estimator" simulation in the world to continually monitor, control, and analyze the state of the power grid and to predict future events and study contingencies. DHS will allow entities such as the MISO to develop simulations which enable new methods for analysis, prediction, and control for security of large scale systems. (Mr. P. Lamm, AFRL/PRPE, (937) 255-4045)

The MISO Control Center



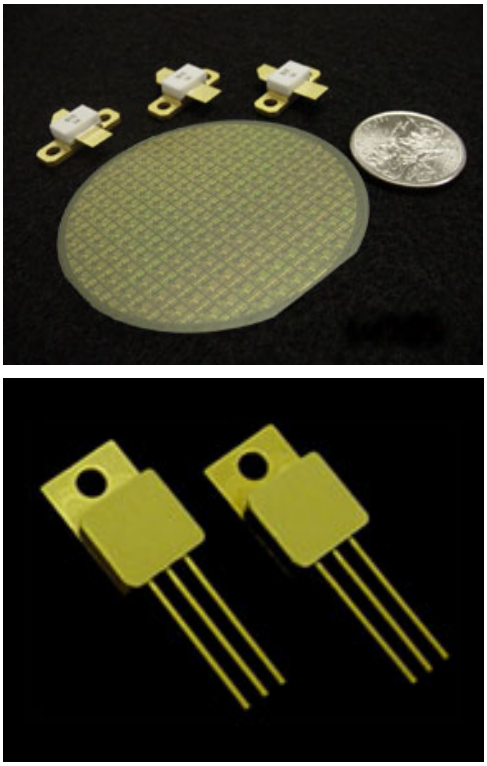
Schematic of the power grid

FABRICATION OF GROUND DEMONSTRATION ENGINE 2 (GDE-2) COMPLETED: Smiths Aerospace of Manchester, Connecticut, recently completed fabrication of the 2nd generation Ground Demonstration Engine, or GDE-2. This scramjet engine was assembled under the Propulsion Directorate's Hydrocarbon Scramjet Engine Technology (HySET) program with Pratt & Whitney. Using lessons learned from GDE-1, GDE-2 was designed and fabricated to demonstrate the operability, structural durability, and engine performance of a complete hydrocarbon-fueled scramjet propulsion system to be tested at Mach 5 and Mach 7. The engine has a single flight-like flowpath with a bolted assembly, composite leading edge, closed-loop fuel system, and moveable inlet cowl flap. The engine is currently being integrated with the forebody, pedestal, and instrumentation. It will then be shipped to NASA Langley Research Center (LaRC) in Hampton, Virginia, to be tested in the NASA LaRC 8-foot High Temperature Tunnel in October 2005 at Mach 5 flight conditions. Major test objectives are to demonstrate the closed loop fuel system, assess inlet performance and operability, assess operational characteristics of the hot gas valves, confirm engine light sequence, and verify design tools. (Ms. P. Pearce, AFRL/PRAT, (937) 255-7294)



The Ground Demonstration Engine 2 (GDE-2)

IMPROVED POWER HANDLING CAPABILITY ACHIEVED: SemiSouth Laboratories, Inc. of Starkville, Mississippi, recently completed initial characterization of silicon carbide (SiC) power Junction Field-Effect Transistor (JFET) switching devices, and they report the achievement of their highest rated current devices to date. These devices were produced on a multi-wafer run conducted under a contract with AFRL's Propulsion Directorate. Several wafers containing large area die (>3 mm^2) have yielded 600 V devices with forward current conduction capability of 50 amps. This accomplishment is significant in that it demonstrates the suitability of the new self-aligned device structure and the quality of their recently developed SiC epitaxial film growth capability. Subsequent to post fabrication yield analysis, delivery of several high current devices will be made for in-house use in converters being designed and built for high temperature characterization. These JFET devices have application to motor drives, converters/inverters, and other electrical power equipment with high temperature operating requirements. The Air Force's More Electric Aircraft has several power system requirements that may be satisfied by this technology. Other applications include motor drives for fuel pumps, high temperature power modules, solid state circuit breakers, radiation tolerant power management and distribution for space platforms, and integrated radar power supplies. (Dr. J. Scofield, AFRL/PRPE, (937) 255-5949)



JFET power devices

MS. REGAZZI RECOGNIZED FOR CONTRIBUTIONS TO SBIR PROGRAM: AFRL's Ms. Laurie Regazzi was recently named the Air Force Small Business Innovation Research (SBIR) Program Manager of the Year by the Air Force SBIR Office. Ms. Regazzi has been the Propulsion Directorate (PR) SBIR

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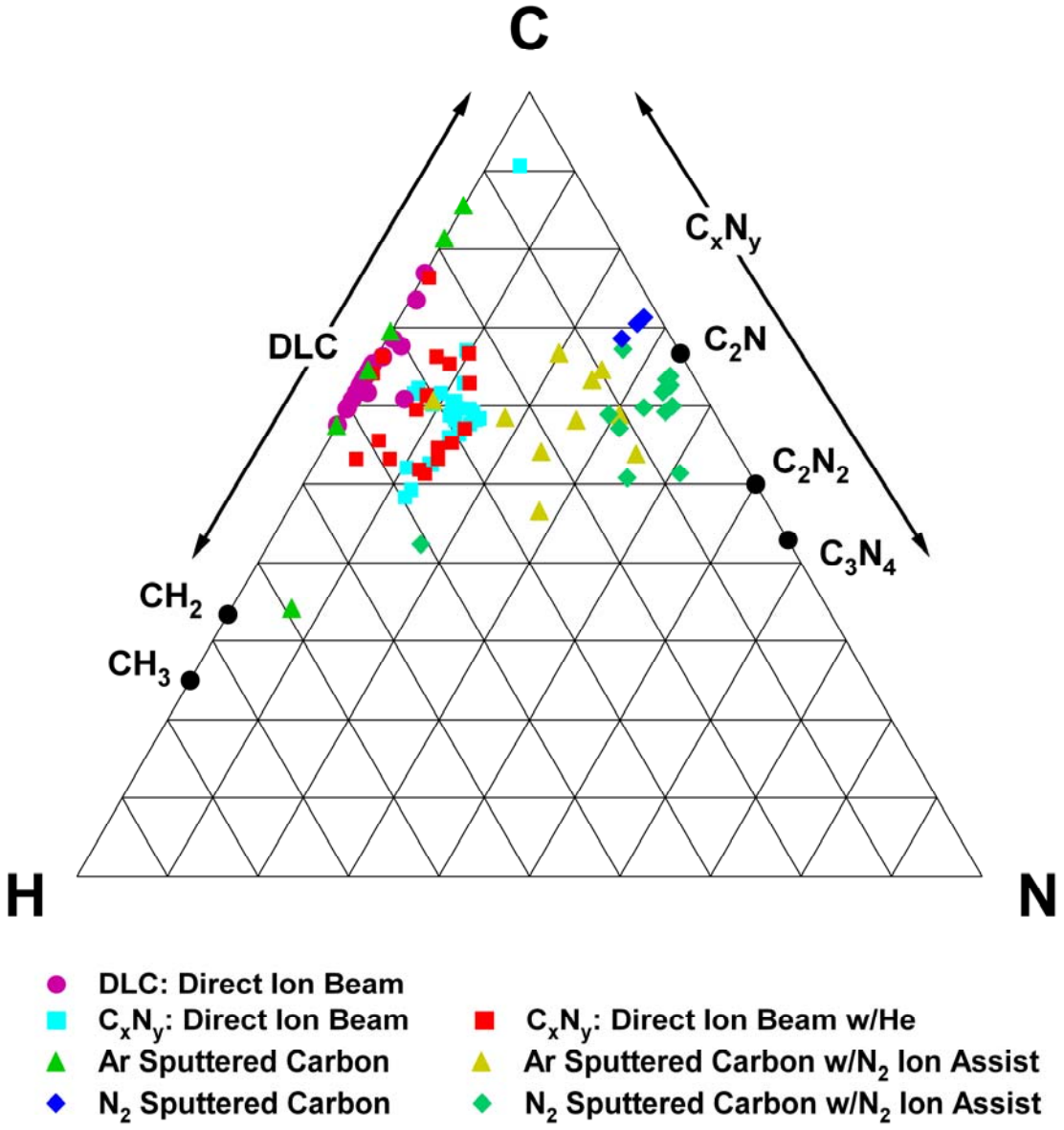
Program Manager for the past three years and, in that time, she has made significant impacts to both the PR and Air Force SBIR programs. She embraced technology to improve the entire SBIR process. She volunteered PR as the testbed for the On-Line Evaluation Web Site, which has been a resounding success, and she also brought the Oz, or Object Czar®, program to PR to help with the preparation of SBIR procurement packages. Under her leadership, the SBIR program grew to the extent that she needed an assistant, so she ably trained and mentored a new assistant. Her training efforts were so effective that the new assistant is now capable of "stepping in" in her absence. Furthermore, she established a close working relationship with the PR Chief Scientist, which has been critical to ensuring that program oversight and program objectives are achieved in a timely manner. Through her demonstrated management, organizational, and team-building skills, Ms. Regazzi has proven herself worthy of this distinguished honor. (Ms. S. Steltz, AFRL/PROB, (937) 255-1889)

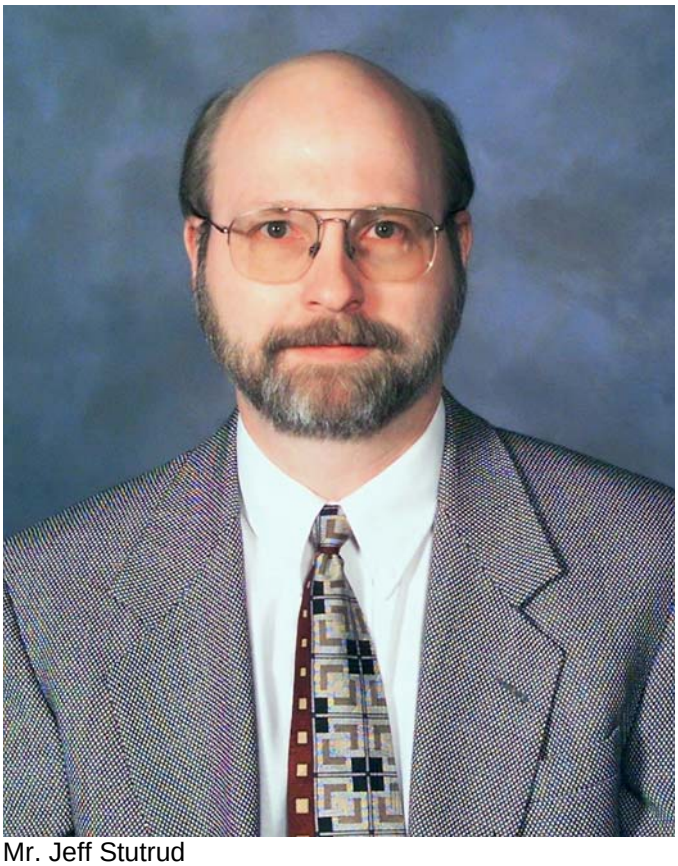
HIGH ELECTRICAL BREAKDOWN STRENGTH IN CN_x FILMS DEMONSTRATED: AFRL is producing amorphous carbon nitride (CN_x) films for possible use as advanced dielectrics for high temperature, high power capacitors. This basic research (6.1) effort is a collaboration between the Propulsion Directorate, Innovative Scientific Solutions, Inc. (ISSI), and Ohio University. Crystalline forms of this material are predicted, theoretically, to be harder than diamond and are expected to provide other characteristics similar to diamond. These characteristics include high thermal conductivity, thermal stability at high operating temperatures, high electrical resistivity, and high electrical breakdown strength. While no reliable predictions exist for the amorphous material, it is reasonable to expect the amorphous material to possess, to some degree, characteristics similar to the crystalline material. This is seen, for example, when comparing films of amorphous diamond-like-carbon (DLC) and crystalline diamond. Previously, films were successfully produced that possessed high temperature stability (600°C); but these films did not possess high electrical breakdown strength, which is a requirement for capacitors. Now for the first time, CN_x films have been produced that show excellent breakdown strength. On a limited number of samples, breakdown strengths were found to be a factor of two better than the best reported values for DLC and within a factor of three of the best reported for diamond. This is the first report of high electrical breakdown

strength in amorphous CN_x films. While reproducibility of the films is still poor, the percentage of "good" films is increasing. (Dr. C. DeJoseph, AFRL/PRPE, (937) 255-2923)



A phase diagram showing the carbon, nitrogen, and hydrogen percentages in amorphous thin films produced using ion-beam deposition. Each corner of the phase diagram represents 100% of a given atomic species. This type of diagram (called a Ternary Diagram) is a convenient method for showing the composition of the films deposited under varying conditions. Such variables as gas mixture, ion-energy, and whether the deposition was done using a single "direct" ion beam, a second "sputter" beam or both ("sputtered with ion assist") dramatically affect the composition and the resulting physical characteristics of the films. Since the films are amorphous as opposed to a well defined crystalline structure, their composition can vary continuously over the space of the diagram. Previous diamond-like-carbon (DLC) results are shown along the C-H side of the triangle. Recent C_xN_y results showing high temperature stability and high electrical breakdown strength have come primarily from the green diamonds shown near the C-N side of the triangle.

MR. STUTRUD RECOGNIZED FOR DATA ACQUISITION EXPERTISE: AFRL's Mr. Jeffrey S. Stutrud was recently selected to receive the Exemplary Civilian Service Award. Mr. Stutrud, a mechanical engineer in the Propulsion Directorate's Combustion Branch (AFRL/PRTC), distinguished himself as the Team Leader for Data Acquisition and Facility Control from January 2000 to January 2005. During this time, Mr. Stutrud and his team made numerous significant advances in the control and safety of six AFRL/PRTC research experiments. They dramatically improved the speed and accuracy with which data is collected for 50 critical test programs with defense contractors, universities, and other government organizations. These facility improvements have been essential in helping to establish AFRL as the premier organization within the US for advanced military combustor development. A recent program of particular national interest is the flight demonstration of a pulsed detonation engine (PDE), for which Mr. Stutrud designed and developed high-quality data acquisition systems. This ongoing flight demonstration program, which will ultimately lead to the first-ever demonstration of a manned PDE-powered aircraft, would not be possible without these critical data acquisition systems. (Dr. R. Hancock, AFRL/PRTC, (937) 255-6814)



Mr. Jeff Stutrud